U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

PAPER BLASTMETERS

1.   OBJECTIVE

The objective of this procedure is to determine the extent of the shock wave or blast effect produced by detonation of a high explosive or by the muzzle blast of a gun.

2.   BACKGROUND

The blast or shock wave produced by detonation of a high explosive, or by the muzzle blast from a gun, may be expressed as a function of time in terms of the static overpressure. Figure 1 shows an idealized pressure-time curve. Before the blast reaches the point where the measurement is taken, the pressure is atmospheric. At the instant the shock arrives, the pressure increases discontinuously to a value designated the "peak overpressure". The pressure then decreases continuously to less than atmospheric pressure and finally rises again to the atmospheric value, where it remains constant. The time between the arrival of the blast and the point at which the pressure first returns to atmospheric is called the "positive pressure duration". The area of the pressure-time curve during this period is known as the "positive impulse" of the blast.

The peak overpressure is a measure of the crushing effect, acting in all directions, from the blast. A wall which faces the explosion is also acted upon by the winds accompanying the blast wave, i.e., a true motion of the air in the direction of propagation, which contributes to the force on such a wall. The wind pressure is the dynamic pressure. This wind has a velocity of about 100 mph when the overpressure is 3 psi. The wind velocity increases with greater pressures. As a result of the dynamic pressure, the peak pressure exerted on a wall facing the blast will be considerably greater than the over-pressure. The relationship of the dynamic pressure to the overpressure is described by the Rankine-Hugoniot equations, The Effects of Nuclear Weapons, U. S. Atomic Energy Commission, April 1962.

The effectiveness of a blast wave is generally measured by either the positive impulse or the peak pressure. For highly elastic structures the former will be effective, while for brittle structures the damage will be de-termined by the latter. Thus, in order to compare the effectiveness of two explosives or to estimate the damage that will be done by a blast wave, it is necessary to measure either the positive impulse, the peak overpressure, or both. Paper blastmeters measure primarily the relative range of peak pressure (i.e. 4 to 5 psi).

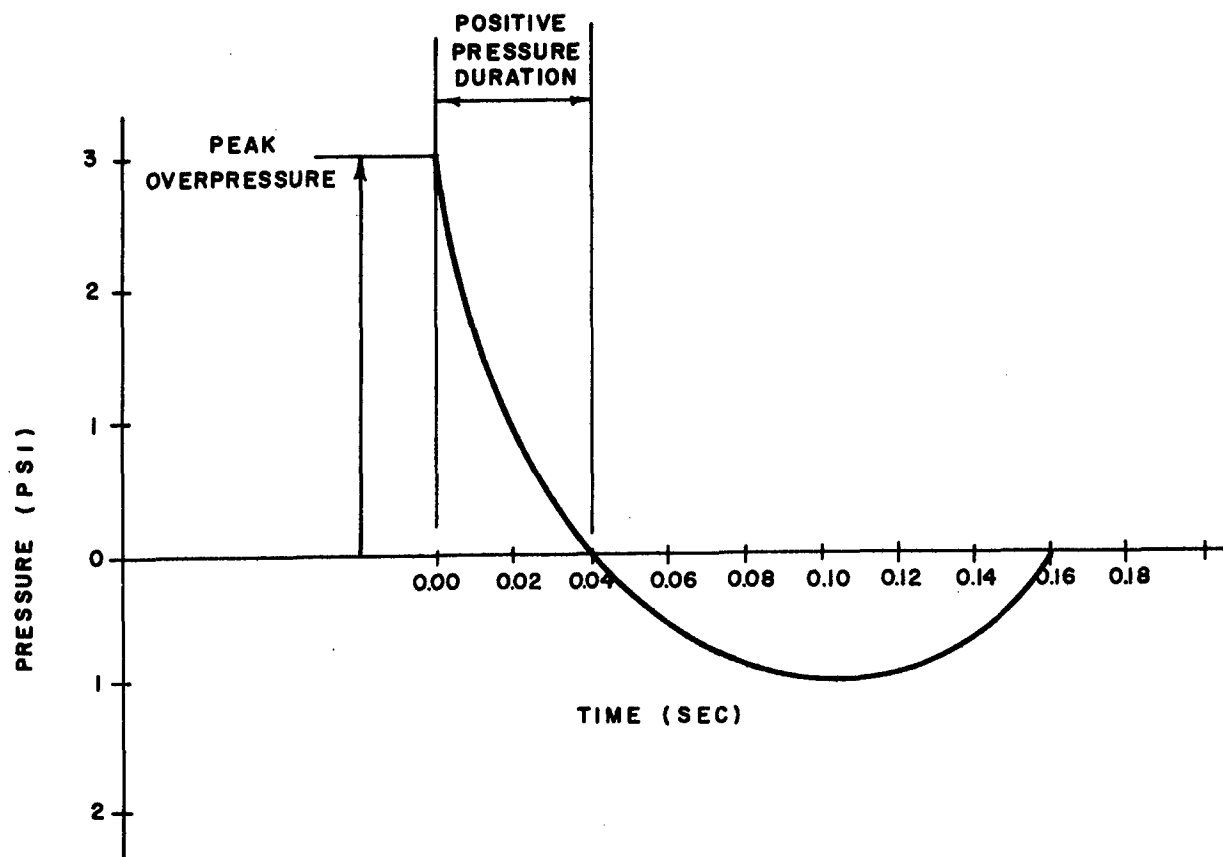*Supersedes Interim Pamphlet 80-13

20020805022

Figure 1.   Idealized Pressure-Time Curve in the Air Blast Wave
of a 4000-Pound Bomb at 300 feet from the Bomb

3.   REQUIRED EQUIPMENT

        a.   Bond Paper, Substance 16, or equivalent
        b.   20 x 11 x 3/4 inch Boards, as required
        c.   2- by 4- inch Posts or equivalent, as required
        d.   Securing Arm, as required
        e.   Bolts and Wing Nuts or Dzus Fasteners, as required

4.   REFERENCES

        A.   Carr, Thomas D., Schwarzschild, Martin, and Weiss, Phil, An Im-
        proved Method for the Measurement of Blast from Bombs, Aberdeen
        Proving Ground, BRL Report 336, 19 April 1943.
        B.   Carr, Thomas D., Weiss, Phil, Johnson, Thomas H., and Sachs,
        Robert G., Measurement of Blast from 10,000-lb. Bombs of Various
        Loadings, Aberdeen Proving Ground, BRL Report 418, 24 October
        1943.

C. Glasstone, S., Editor, The Effects of Nuclear Weapons, U. S. Atomic Energy Commission, April 1962.

D. Ryerson, C. M., Direct Reading Blast Gage, Naval Ordnance Laboratory Memorandum 3598, Washington, D. C., 25 April 1943.

E. Sacks, Robert G., The Calibration of Paper Blastmeters, Aberdeen Proving Ground, BRL Report 472, 20 June 1944.

F. Sachs, Robert G., Method for Comparing Bombs by Means of Paper Blastmeters, Aberdeen Proving Ground, BRL Memorandum Report 186, 1 July 1943.

G. MTP 4-2-822, Air Blast Pressure Measurement-Electronic.

H. MTP 3-2-811, Noise and Blast Measurements.

I. Aberdeen Proving Ground D & PS Drawings - DS 5897D, DS-5898D, and DS-6459C.

5.   SCOPE

5.1   SUMMARY

        The procedures in this document describe the use of paper blastmeters as well as the way in which they are constructed.

5.2   LIMITATIONS

        Paper blastmeters are used for measuring blast on special occasions when the accuracy achievable by the electronic method is not required, and for delineating problem areas indicating the need for more refined instrumentation. Blastmeter tests are of interest, for example, in the determination of the order of an explosion or for obtaining an approximate measurement of pressure. More accurate electronic means of measuring blast effects are described in MTP's 3-2-811 and 4-2-822.

6.   PROCEDURE

6.1   PREPARATION FOR TEST

6.1.1   Construction of Paper Blastmeters

        Construct a minimum of two sets of paper blastmeter (ten blastmeters per set) using the following procedures for each blastmeter:

        a. Clamp two 20- by -11 by 3/4 inch boards together and drill the following holes:

                1) Ten circles of different diameters as indicated in Figure 2 (top picture) and Figure 3.
                2) Ten equispaced mounting holes, for bolts and wingnuts or Dzus fasteners as indicated in Figure 3.

        b. Place a sheet of bond paper, substance 16 or equivalent, between the boards and bolt the boards together using wing nuts or Dzus fasterners (See

Figure 3).

NOTE: The bond paper forms the "diaphragms" of the blastmeter.

c. Prepare a securing arm as shown in Figure 2 (middle picture) and Figure 3 and fit it to the blastmeter.

NOTE: Complete fabrication details are shown in Aberdeen Proving Ground D & PS Drawings DS-5897D, DS-5898D and DS-6459C (reference 4I).

d. Store the blastmeters in a dry place until ready for use.

NOTE: 1. Two sets are desired so that the paper in one set can be changed while the second set is being used.
       2. Replacements should be available because some blastmeters will be struck by fragments.

6.1.2   Preparation For Firing

Install the blastmeters in the position at which the pressure is to be measured as follows:

a. Set up the 2- by-4 inch supporting posts. Positioning of the posts is dependent upon the test to be run:

1) Place the posts in a direct line if they are to be spread in intervals of ten feet or more from each other.
2) Stagger the posts if they are to be spaced in intervals of less than ten feet from each other.

b. Assemble the blastmeter to the supporting posts and observe the following:

1) Do not mount the blastmeters prior to one hour before test time nor during objectional weather conditions (i.e., rain, snow, blowing snow or sand, or high relative humidity).
2) Mount the blastmeter to the supporting post so that the face of the blastmeter is turned toward the direction from which the blast is to come. Wing nuts or Dzus fasteners shall face away from the blast areas.
3) There shall be no obstruction (e.g., gun muzzle) between the blast and the blastmeters.

6.2   TEST CONDUCT

6.2.1   Explosive Charges

6.2.1.1 a. Prepare the weapon to be used to propel the projectile so that the projectile explodes within the prescribed area as defined by the blastmeter
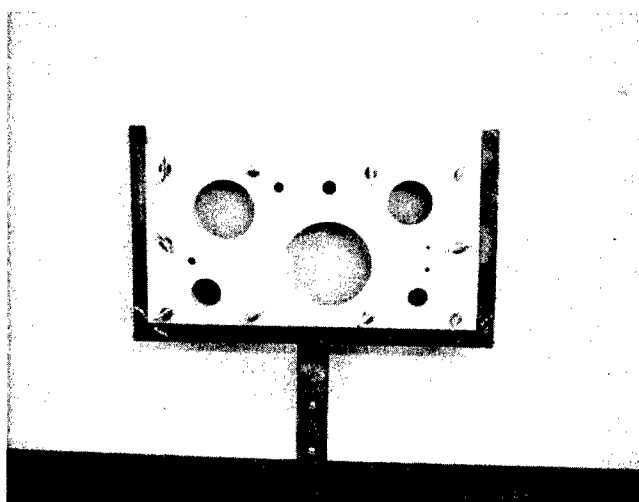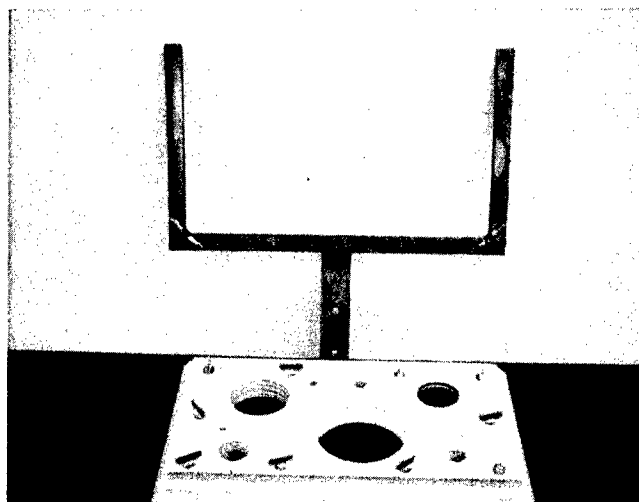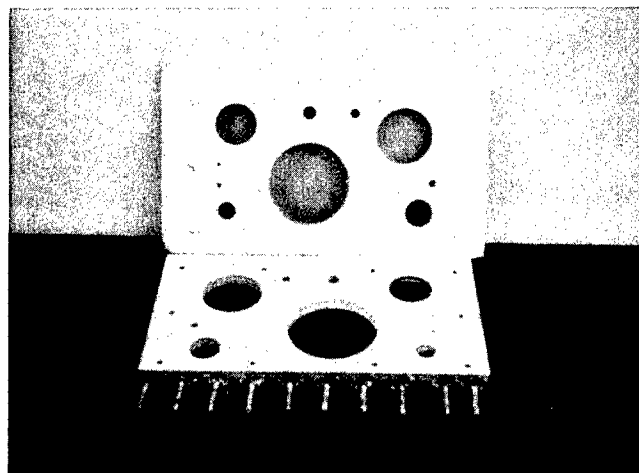
Figure 2.   Views of a Paper Blastmeter

PAPER

TOP VIEW

5/8   7/8

3-3/4   2-3/4

1/4

5-3/8   5/16

1/2

1-7/8   1-1/4

BLASTMETER
DS-5898-D

MOUNTING BRACKET
DS-6459-C

2 x 4 MOUNTING
POST

3/8 x 3 MOUNTING
BOLTS

HALF SIZE
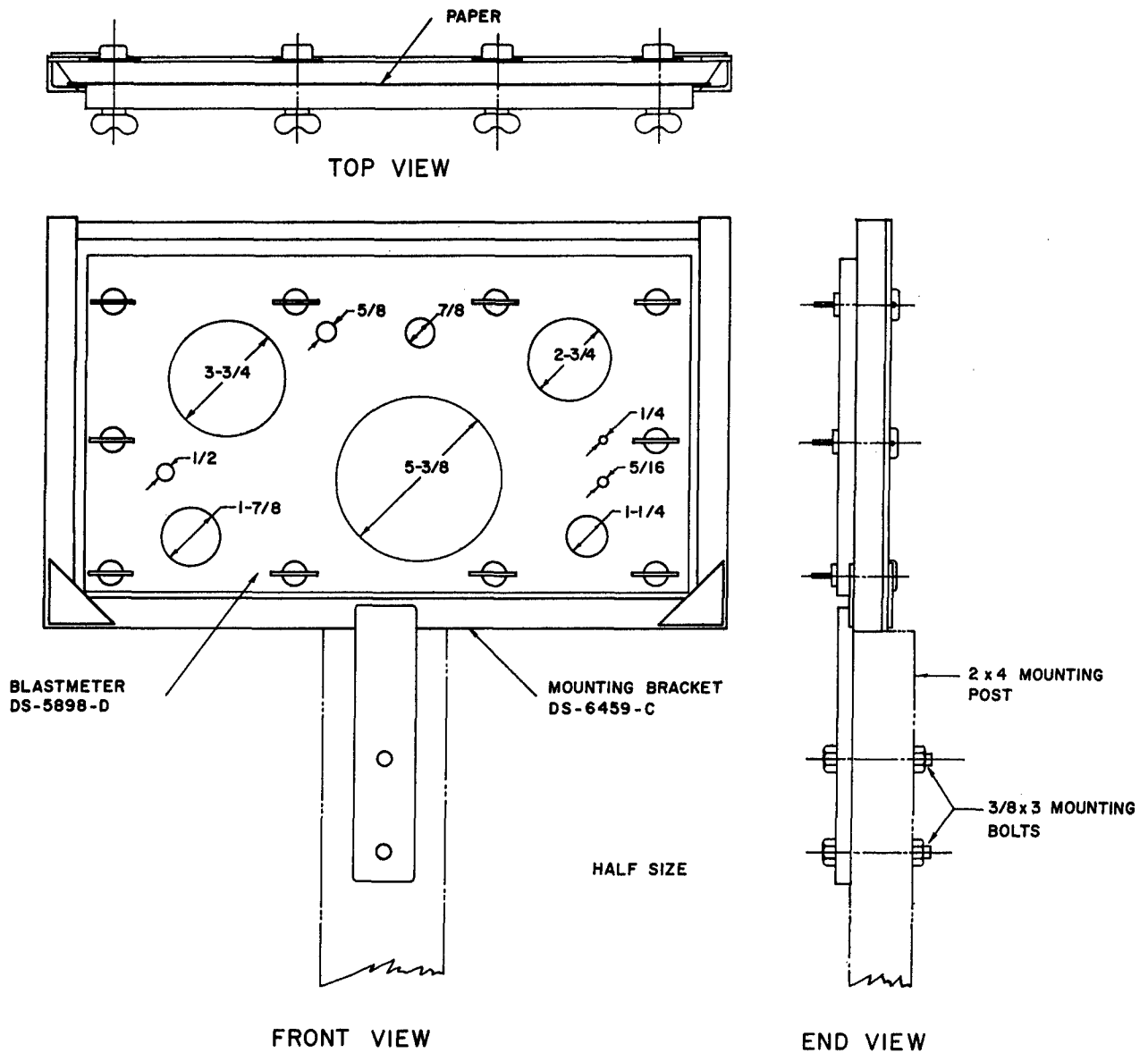
FRONT VIEW   END VIEW

Figure 3.   Diagram of Paper Blastmeter and Securing Arm

placement.

   b. Record the following:

     1) Test weapon
     2) Projectile type

   c. Fire the test weapon and record the following:

     1) Exact distance of all blastmeters from the projectile's point
       of impact.
     2) Number of diaphragms broken in each blastmeter.

   d. Repeat step c for a minimum of one more projectile.

   NOTE: If comparative testing is to be performed, the rounds to be
       compared are fired alternately.

6.2.1.2 Non-Projectile Explosive Charges

   a. Set the explosive charge in a predetermined area, as defined by
the blastmeters and record the following:

     1) Device under test
     2) Purpose of device
     3) Exact distance of all blastmeters from the explosive charge.

   b. Detonate the explosive and record the number of diaphragms broken
in each blastmeter.

6.2.2 Direct Measurement of Pressure Caused by Muzzle Blast

   a. After emplacing the weapon, locate the blastmeters so that they
face normal to the direction of the blast pressure shockwave (i.e. face-on
pressures).
   b. Record the following:

     1) Weapon under test
     2) Exact distance of all blastmeters from the source of the
       blast.

6.2.2.1 Single Charge Weapons

   a. Fire a minimum of two rounds and record the number of diaphragms
broken in each blastmeter.

6.2.2.2 Multiple Charge Weapons

   a. Fire a minimum of two rounds with minimum charge.
   b. Record the number of diaphragms broken in each blastmeter.
   c. Repeat steps a and b for the remaining charges.

6.3   TEST DATA

6.3.1   Explosive Charges

6.3.1.1   Projectiles

Record the following:

a. Test weapon (155 mm Howitzer)
b. Projectile type (HE)
c. For each round fired:

1) Round number (1, 2)
2) Exact distance of all blastmeters from point of impact in feet
3) Number of diaphragms broken in each blastmeter

6.3.1.2   Non-Projectile Explosive Charges

Record the following:

a. Device under test (Mine)
b. Purpose of device (Anti-personnel)
c. Exact distance of all blastmeters from the explosive charge in feet
d. Number of diaphragms broken in each blastmeter

6.3.2   Direct Measurement of Pressure Caused by Muzzle Blast

Record the following:

a. Weapon under test (155 Howitzer)
b. Exact distance of all blastmeters from the source of the blast in feet.

6.3.2.1   Single Charge Weapons

Record the following:

a. Round number
b. The number of diaphragms broken in each blastmeter

6.3.2.2   Multiple Charge Weapons

Record the following:

a. Round number
b. Charge number
c. The number of diaphragms broken in each blastmeter for each charge

6.4   DATA REDUCTION AND PRESENTATION

6.4.1   Evaluation of Individual Charges

Paper blastmeters measure the blast by the rupturing of paper dia-phragms of various diameters. The larger the diameter of the diaphragm, the more easily it will be broken. Therefore, for a weak blast, only the larger diaphragms will be broken; as the blast increases in strength, the size of diaphragm broken becomes smaller. The strength of the blast as measured in this way can be indicative of the peak pressure in the blast. This use of the blastmeter is applicable to muzzle blast from guns as well as to the blast of high explosives. A rough calibration of the paper blastmeters, expressed in terms of the peak pressure required to break a given diaphragm, is shown below.

Pressure Required to Blow Out Holes in Standard Paper Blastmeter

No. of Holes	1	2	3	4	5	6	7	8	9	10
Pressure (psi)	1.0	1.4	1.9	2.7	3.7	5.2	7.3	10	14	20

6.4.2   Average of Charges

The quantity recorded is the number of holes blown out of the blast-meter. The quantity usually calculated is R_4, the average distance at which the four largest holes would be blown out. Actually the average logarithm of this distance is used, and it is obtained from the relation:

$$\log R = \text{average } \log R - 0.0244 \left(16 - \frac{N}{n}\right) \tag{1}$$

where "average log R" = average value of the logarithm of the distances from
the explosive charge to where the blastmeters are
placed,

n = number (usually 10) of blastmeters in a line,

N = total number of holes blown out in all blastmeters.

For a more detailed discussion of blastmeter calibration, see Reference 4E.

6.4.3   Comparison of Charges

As pointed out, it is clear that the larger the value of R_4, the more effective the explosive charge. A quantitative measure of the difference may be obtained by using the experimental fact that the peak pressure decreases, roughly, as 3/2 power of the distance. This leads to the result that the per-cent difference in peak pressure between explosive charges at a distance near R_4 is given by

$$\text{Percent difference} = 345 \left(\log R_4{}^{(2)} - \log R_4{}^{(1)}\right) \tag{2}$$

where $\log R_4{}^{(1)}$ = value of log R_4 obtained for the first explosive
charge

and $\log R_4{}^{(2)}$ = value obtained for the second explosive charge.

This formula is to be applied only when the difference is less than 25 percent.

By making use of equation (1), equation (2) can be rewritten in the

form:

$$\text{Percent difference} = \frac{8.42}{n} N(2) - N(1) \qquad (3)$$

where $N(1)$ = total number of holes blown out by the one explosive charge

and $N(2)$ = corresponding number for the other explosive charge.